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Network science: a useful tool in economics and finance

Published: 05 May 2015

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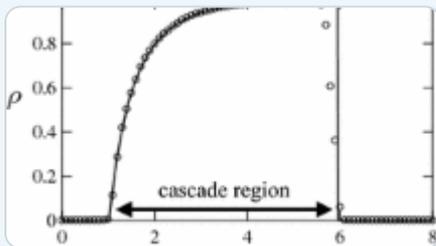
Abstract

The increasing frequency and scope of financial crises has made global financial stability one of the major concerns of economic policy and decision makers. Under this highly complex environment, supervision of the financial system has to be thought of as a systemic task, focusing not only on the strength of the institutions but also on the interdependent relations among them, unraveling the structure and dynamic of the system as a whole. In recent years, network science has emerged as a leading tool for the investigation of complex systems. Here we review several applications of network science in finance and economics, and discuss existing challenges and future directions which will substantiate network science as a key tool for financial academics, practitioners, and policy and decision makers.

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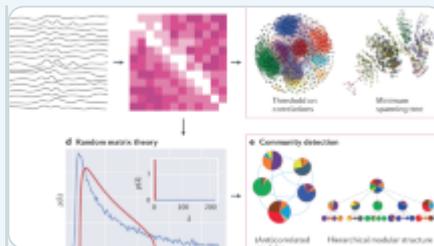
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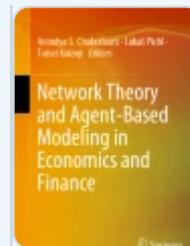
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References

Acemoglu D, Malekian A, Ozdaglar A (2013a) Network security and contagion. Technical report, National Bureau of Economic Research

Acemoglu D, Ozdaglar A, Tahbaz-Salehi A (2013b) The network origins of large economic downturns. Technical report, National Bureau of Economic Research

Acemoglu D, Ozdaglar A, Tahbaz-Salehi A (2013c) Systemic risk and stability in financial networks. Technical report, National Bureau of Economic Research

Aguiar A, Bookstaber R, Wipf T (2014) A map of funding durability and risk. Off Financ Res Work Pap Ser 14(03)

Albert R, Barabási A-L (2002) Statistical mechanics of complex networks. Rev Mod Phys 74(1):47

[Article](#) [MATH](#) [ADS](#) [Google Scholar](#)

Allen F, Gale D (1998) Optimal financial crises. J Financ 53(4):1245–1284

[Article](#) [Google Scholar](#)

Amini H, Cont R, Minca A (2012) Stress testing the resilience of financial networks. Int J Theor Appl Financ 15(01)

Amman HM, Tesfatsion L, Judd KL, Kendrick DA, Rust J (2006) Handbook of computational economics, vol 2. Elsevier, Amsterdam

[Google Scholar](#)

Arenas A, Díaz-Guilera A, Kurths J, Moreno Y, Zhou C (2008) Synchronization in complex networks. Phys Rep 469(3):93–153

[Article](#) [MathSciNet](#) [ADS](#) [Google Scholar](#)

Barabási A-L, Albert R (1999) Emergence of scaling in random networks. Science 286(5439):509–512

Barabási A-L, Frangos J (2014) *Linked: the new science of networks*. Basic Books, New York

[Google Scholar](#)

Bargigli L, Di Iasio G, Infante L, Lillo F, Pierobon F (2015) The multiplex structure of interbank networks. *Quant Financ* 15(4):673–691

[Article](#) [Google Scholar](#)

Barrat A, Barthelemy M, Pastor-Satorras R, Vespignani A (2004) The architecture of complex weighted networks. *Proc Natl Acad Sci USA* 101(11):3747–3752

[Article](#) [PubMed Central](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Bashan A, Bartsch RP, Kantelhardt JW, Havlin S, Ivanov PC (2012) Network physiology reveals relations between network topology and physiological function. *Nat Commun* 3:702

[Article](#) [PubMed Central](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Battiston S, Puliga M, Kaushik R, Tasca P, Caldarelli G (2012) Debtrank: too central to fail? Financial networks, the fed and systemic risk. *Sci Rep* 2

Billio M, Getmansky M, Lo AW, Pelizzon L (2012) Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *J Financ Econ* 104(3):535–559

[Article](#) [Google Scholar](#)

Boccaletti S, Latora V, Moreno Y, Chavez M, Hwang D-U (2006) Complex networks: structure and dynamics. *Phys Rep* 424(4):175–308

Boccaletti S, Bianconi G, Criado R, Del Genio C, Gómez-Gardeñes J, Romance M, Sendiña-Nadal I, Wang Z, Zanin M (2014) The structure and dynamics of multilayer networks. Phys Rep 544(1):1-122

[Article](#) [MathSciNet](#) [ADS](#) [Google Scholar](#)

Bonanno G, Caldarelli G, Lillo F, Mantegna RN (2003) Topology of correlation-based minimal spanning trees in real and model markets. Phys Rev E 68(4):046130

[Article](#) [ADS](#) [Google Scholar](#)

Bookstaber RM, Kenett DY (2015) The multilayer structure of the financial system (preprint)

Bookstaber R, Paddrik M, Tivnan B (2014) An agent based model for financial vulnerability. Off Financ Res Work Pap Ser 14(05)

Bookstaber R, Glasserman P, Iyengar G, Luo Y, Venkatasubramanian V, Zhang Z (2015) Process systems engineering as a modeling paradigm for analyzing systemic risk in financial networks. Off Financ Res Work Pap Ser 15(01)

Borgatti SP, Everett MG (2000) Models of core/periphery structures. Soc Netw 21(4):375-395

[Article](#) [Google Scholar](#)

Boss M, Elsinger H, Summer M, Thurner S IV (2004) Network topology of the interbank market. Quant Financ 4(6):677-684

[Article](#) [Google Scholar](#)

Buldyrev SV, Parshani R, Paul G, Stanley HE, Havlin S (2010) Catastrophic cascade of failures in interdependent networks. *Nature* 464(7291):1025–1028

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Caldarelli G (2007) *Scale-free networks: complex webs in nature and technology*. Oxford University Press, Oxford

Cantono S, Solomon S (2010) When the collective acts on its components: economic crisis autocatalytic percolation. *N J Phys* 12(7):075038

[Article](#) [Google Scholar](#)

Cepeda F (2008) La topología de redes como herramienta de seguimiento en el sistema de pagos de alto valor en Colombia. *Borradores de Economía* 513

Cohen R, Erez K, Ben-Avraham D, Havlin S (2000) Resilience of the internet to random breakdowns. *Phys Rev Lett* 85(21):4626

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Cohen R, Havlin S, Ben-Avraham D (2003) Efficient immunization strategies for computer networks and populations. *Phys Rev Lett* 91(24):247901

[Article](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Cohen R, Havlin S (2010) *Complex networks: structure, robustness and function*. Cambridge University Press, Cambridge

[Book](#) [Google Scholar](#)

Cont R (2013) Networks: introduction. In: Fouque JP, Langsam JA (eds) *Handbook on systemic risk*, vol 285. Cambridge University Press, Cambridge

Cont R, Moussa A, Santos EB et al (2013) Network structure and systemic risk in banking systems. In: Handbook of systemic risk. Cambridge University Press, Cambridge, pp 327–368

Craig B, Von Peter G (2014) Interbank tiering and money center banks. J Financ Intermed 23(3):322–347

[Article](#) [Google Scholar](#)

Curme C, Tumminello M, Mantegna RN, Stanley HE, Kenett DY (2015) Emergence of statistically validated financial intraday lead-lag relationships. Quant Financ. doi:[10.1080/14697688.2015.1032545](https://doi.org/10.1080/14697688.2015.1032545)

[MathSciNet](#) [Google Scholar](#)

Drehmann M, Tarashev N (2013) Measuring the systemic importance of interconnected banks. J Financ Intermed 22(4):586–607

[Article](#) [Google Scholar](#)

Elsinger H, Lehar A, Summer M (2005) Using market information for banking system risk assessment. Available at SSRN: 787929

Elsinger H, Lehar A, Summer M (2006) Risk assessment for banking systems. Manag Sci 52(9):1301–1314

[Article](#) [MATH](#) [Google Scholar](#)

Erdős P, Rényi A (1959) On random graphs. Publicat Math Debr 6:290–297

[Google Scholar](#)

Faloutsos M, Faloutsos P, Faloutsos C (1999) On power-law relationships of the internet topology. In: ACM SIGCOMM computer communication review, vol 29.

Fricke D, Lux T (2015) Core-periphery structure in the overnight money market: evidence from the e-mid trading platform. *Comput Econ* 45:359-395

[Article](#) [Google Scholar](#)

Furfine CH (2003) Interbank exposures: quantifying the risk of contagion. *J Money Credit Bank* 35(1):111-128

[Article](#) [Google Scholar](#)

Galbiati M, Soramäki K (2012) Clearing networks. *J Econ Behav Organ* 83(3):609-626

[Article](#) [Google Scholar](#)

Gao J, Buldyrev SV, Stanley HE, Havlin S (2012) Networks formed from interdependent networks. *Nat Phys* 8(1):40-48

[Article](#) [CAS](#) [Google Scholar](#)

Garas A, Argyrakis P, Havlin S (2008) The structural role of weak and strong links in a financial market network. *Eur Phys J B Condens Matter Complex Syst* 63(2):265-271

[Article](#) [MATH](#) [CAS](#) [Google Scholar](#)

Garas A, Argyrakis P, Rozenblat C, Tomassini M, Havlin S (2010) Worldwide spreading of economic crisis. *N J Phys* 12(11):113043

[Article](#) [Google Scholar](#)

Glasserman P, Young HP (2015) How likely is contagion in financial networks? *J Bank Financ* 50:383-399

Haldane AG et al (2009) Rethinking the financial network. Financial Student Association, Amsterdam

[Google Scholar](#)

Haldane AG, May RM (2011) Systemic risk in banking ecosystems. Nature 469(7330):351-355

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Havlin S, Kenett DY, Ben-Jacob E, Bunde A, Cohen R, Hermann H, Kantelhardt J, Kertész J, Kirkpatrick S, Kurths J et al (2012) Challenges in network science: applications to infrastructures, climate, social systems and economics. Eur Phys J Spec Top 214(1):273

[Article](#) [Google Scholar](#)

Helbing D (2013) Globally networked risks and how to respond. Nature 497(7447):51-59

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Huang X, Vodenska I, Havlin S, Stanley HE (2013) Cascading failures in bi-partite graphs: model for systemic risk propagation. Sci Rep 3

Hüser A-C (2015) Too interconnected to fail: a survey of the interbank networks literature. SAFE working paper no. 91 (available at SSRN 2577241)

Inaoka H, Ninomiya T, Taniguchi K, Shimizu T, Takayasu H (2004) Fractal network derived from banking transaction-an analysis of network structures formed by financial institutions. Bank Jpn Work Pap 4

Iñiguez G, Kertész J, Kaski KK, Barrio R (2009) Opinion and community formation in coevolving networks. Phys Rev E 80(6):066119

[Article](#) [ADS](#) [Google Scholar](#)

Iori G, De Masi G, Precup OV, Gabbi G, Caldarelli G (2008) A network analysis of the italian overnight money market. J Econ Dyn Control 32(1):259-278

[Article](#) [MATH](#) [Google Scholar](#)

Jackson MO (2010) Social economic networks. Princeton University Press, Princeton

[MATH](#) [Google Scholar](#)

Kenett DY, Tumminello M, Madi A, Gur-Gershgoren G, Mantegna RN, Ben-Jacob E (2010) Dominating clasp of the financial sector revealed by partial correlation analysis of the stock market. PloS One 5(12):15032

[Article](#) [ADS](#) [Google Scholar](#)

Kenett DY, Shapira Y, Madi A, Bransburg-Zabary S, Gur-Gershgoren G, Ben-Jacob E (2011) Index cohesive force analysis reveals that the us market became prone to systemic collapses since 2002. PloS One 6(4):19378

[Article](#) [ADS](#) [Google Scholar](#)

Kenett DY, Preis T, Gur-Gershgoren G, Ben-Jacob E (2012a) Dependency network and node influence: application to the study of financial markets. Int J Bifurc Chaos 22(7):1250181

[Article](#) [Google Scholar](#)

Kenett DY, Raddant M, Zatlavi L, Lux T, Ben-Jacob E (2012b) Correlations in the global financial village. Int J Mod Phys Conf Ser 16(1):13-28

[Article](#) [Google Scholar](#)

Kenett DY, Raddant M, Lux T, Ben-Jacob E (2012c) Evolvment of uniformity and volatility in the stressed global financial village. PloS One 7(2):31144

[Article](#) [ADS](#) [Google Scholar](#)

Kenett DY, Gao J, Huang X, Shao S, Vodenska I, Buldyrev SV, Paul G, Stanley HE, Havlin S (2014) Network of interdependent networks: overview of theory and applications. In: D'Agostino G, Scala A (eds) Networks of networks: the last frontier of complexity. Springer, Berlin, pp 3–36

Langfield S, Liu Z, Ota T (2012) Mapping the UK interbank system (manuscript). UK Financial Sevices Authority

LeBaron B (2006) Agent-based computational finance. Handb Comput Econ 2:1187–1233

[Article](#) [Google Scholar](#)

Levy Carciente S, Kenett DY, Avakian A, Stanley HE, Havlin S (2014) Dynamical macro-prudential stress testing using network theory (available at SSRN 2482742)

Li D, Fu B, Wang Y, Lu G, Berezin Y, Stanley HE, Havlin S (2015) Percolation transition in dynamical traffic network with evolving critical bottlenecks. Proc Natl Acad Sci 112(3):669–672

[Article](#) [PubMed Central](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Li W, Kenett DY, Yamasaki K, Stanley HE, Havlin S (2014) Ranking the economic importance of countries and industries (preprint). [arXiv:1408.0443](#)

Liljeros F, Edling CR, Amaral LAN, Stanley HE, Åberg Y (2001) The web of human sexual contacts. *Nature* 411(6840):907–908

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Lillo F (2010) Networks in finance. In: Encyclopedia of life support systems (EOLSS), developed under the auspices of the UNESCO. Eolss Publishers, Oxford, UK

Lillo F, Moro E, Vaglica G, Mantegna RN (2008) Specialization and herding behavior of trading firms in a financial market. *N J Phys* 10(4):043019

[Article](#) [MathSciNet](#) [Google Scholar](#)

Ludescher J, Gozolchiani A, Bogachev MI, Bunde A, Havlin S, Schellnhuber HJ (2014) Very early warning of next el niño. *Proc Natl Acad Sci* 111(6):2064–2066

[Article](#) [PubMed Central](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Majdandzic A, Podobnik B, Buldyrev SV, Kenett DY, Havlin S, Stanley HE (2014) Spontaneous recovery in dynamical networks. *Nat Phys* 10(1):34–38

[Article](#) [CAS](#) [Google Scholar](#)

Mantegna RN (1999) Hierarchical structure in financial markets. *Eur Phys J B Condens Matter Complex Syst* 11(1):193–197

[Article](#) [CAS](#) [Google Scholar](#)

Martínez Jaramillo S, Kabadjova B, Bravo Benítez B, Solórzano Margain J (2012) Systemic risk analysis by means of network theory: an empirical study of the Mexican banking system. Technical report, Banco de México working papers

Milo R, Shen-Orr S, Itzkovitz S, Kashtan N, Chklovskii D, Alon U (2002) Network

motifs: simple building blocks of complex networks. Science 298(5594):824–827

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Minoiu C, Reyes JA (2011) Network analysis of global banking: 1978–2009. International Monetary Fund

Mu G-H, Zhou W-X, Chen W, Kertész J (2010) Order flow dynamics around extreme price changes on an emerging stock market. N J Phys 12(7):075037

[Article](#) [Google Scholar](#)

Nardini C, Kozma B, Barrat A (2008) Whos talking first? Consensus or lack thereof in coevolving opinion formation models. Phys Rev Lett 100(15):158701

[Article](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Newman MEJ (2009) Networks: an introduction. Oxford University Press, Oxford

[Google Scholar](#)

Newman MEJ, Barabasi A-L, Watts DJ (2011) The structure and dynamics of networks. Princeton University Press, Princeton

[Google Scholar](#)

Nier E, Yang J, Yorulmazer T, Alentorn A (2007) Network models and financial stability. J Econ Dyn Control 31(6):2033–2060

[Article](#) [MATH](#) [Google Scholar](#)

Onnela JP, Chakraborti A, Kaski K, Kertesz J (2003a) Dynamic asset trees and black monday. Phys A Stat Mech Appl 324(1):247–252

[Article](#) [MATH](#) [MathSciNet](#) [Google Scholar](#)

Onnela JP, Chakraborti A, Kaski K, Kertész J, Kanto A (2003b) Dynamics of market correlations: taxonomy and portfolio analysis. Phys Rev E 68(5):056110

[Article](#) [ADS](#) [Google Scholar](#)

Onnela J-P, Saramäki J, Hyvönen J, Szabó G, Lazer D, Kaski K, Kertész J, Barabási A-L (2007) Structure and tie strengths in mobile communication networks. Proc Natl Acad Sci 104(18):7332-7336

[Article](#) [PubMed Central](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Parshani R, Buldyrev SV, Havlin S (2010) Interdependent networks: reducing the coupling strength leads to a change from a first to second order percolation transition. Phys Rev Lett 105(4):048701

[Article](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Parshani R, Dickison M, Cohen R, Stanley HE, Havlin S (2010) Dynamic networks and directed percolation. Europhys Lett 90(3):38004

[Article](#) [ADS](#) [Google Scholar](#)

Pastor-Satorras R, Vespignani A (2001) Epidemic spreading in scale-free networks. Phys Rev Lett 86(14):3200-3203

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Pastor-Satorras R, Vespignani A (2007) Evolution and structure of the internet: a statistical physics approach. Cambridge University Press, Cambridge

[Google Scholar](#)

Radicchi F, Fortunato S, Castellano C (2008) Universality of citation distributions: toward an objective measure of scientific impact. Proc Natl Acad Sci 105(45):17268-17272

Reis SD, Hu Y, Babino A, Andrade JS Jr, Canals S, Sigman M, Makse HA (2014) Avoiding catastrophic failure in correlated networks of networks. *Nat Phys* 10:762–767

[Article](#) [CAS](#) [Google Scholar](#)

Sandaval L Jr, Franca IDP (2012) Correlation of financial markets in times of crisis. *Stat Mech Appl* 391(1):187–208

[Article](#) [Google Scholar](#)

Sandoval L (2014) Structure of a global network of financial companies based on transfer entropy. *Entropy* 16(8):4443–4482

[Article](#) [ADS](#) [Google Scholar](#)

Sendiña-Nadal I, Ofran Y, Almendral JA, Buldú JM, Leyva I, Li D, Havlin S, Boccaletti S (2011) Unveiling protein functions through the dynamics of the interaction network. *PLoS One* 6(3):17679

[Article](#) [ADS](#) [Google Scholar](#)

Shai S, Kenett DY, Kenett YN, Faust M, Dobson S, Havlin S (2014) Resilience of modular complex networks (preprint). [arXiv:1404.4748](https://arxiv.org/abs/1404.4748)

Shao J, Buldyrev SV, Braunstein LA, Havlin S, Stanley HE (2009) Structure of shells in complex networks. *Phys Rev E* 80(3):036105

[Article](#) [ADS](#) [Google Scholar](#)

Solomon S, Weisbuch G, de Arcangelis L, Jan N, Stauffer D (2000) Social percolation models. *Phys A Stat Mech Appl* 277(1):239–247

Song C, Havlin S, Makse HA (2005) Self-similarity of complex networks. Nature 433(7024):392-395

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Soramäki K, Bech ML, Arnold J, Glass RJ, Beyeler WE (2007) The topology of interbank payment flows. Phys A Stat Mech Appl 379(1):317-333

[Article](#) [Google Scholar](#)

Tesfatsion L (2002) Agent-based computational economics: growing economies from the bottom up. Artif Life 8(1):55-82

[Article](#) [MathSciNet](#) [PubMed](#) [Google Scholar](#)

Tesfatsion L (2003) Agent-based computational economics: modeling economies as complex adaptive systems. Inf Sci 149(4):262-268

[Article](#) [Google Scholar](#)

Tumminello M, Coronello C, Lillo F, Micciche S (2007a) Spanning trees and bootstrap reliability estimation in correlation based networks. Int J Bifurc Chaos 17:2319-2329

[Article](#) [MATH](#) [Google Scholar](#)

Tumminello M, Di Matteo T, Aste T, Mantegna R (2007b) Correlation based networks of equity returns sampled at different time horizons. Eur Phys J B Condens Matter Complex Syst 55(2):209-217

[Article](#) [MATH](#) [CAS](#) [Google Scholar](#)

Tumminello M, Lillo F, Mantegna RN (2010) Correlation, hierarchies, and

networks in financial markets. *J Econ Behav Organ* 75(1):40–58

[Article](#) [Google Scholar](#)

Upper C, Worms A (2004) Estimating bilateral exposures in the German interbank market: is there a danger of contagion? *Eur Econ Rev* 48(4):827–849

[Article](#) [Google Scholar](#)

Wells S (2002) UK interbank exposures: systemic risk implications. *Financ Stab Rev* 13:175–182

[Google Scholar](#)

Yamasaki K, Gozolchiani A, Havlin S (2008) Climate networks around the globe are significantly affected by El Nino. *Phys Rev Lett* 100(22):228501

[Article](#) [CAS](#) [PubMed](#) [ADS](#) [Google Scholar](#)

Acknowledgments

We thank Richard Bookstaber and Mark Flood for fruitful conversations and insights related to this paper. We acknowledge financial support from Office of Naval Research (ONR), DTRA, BSF, the LINC (No. 289447) and the Multiplex (No. 317532) EU projects, the DFG, and the Israel Science Foundation.

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Cite this article

Kenett, D.Y., Havlin, S. Network science: a useful tool in economics and finance. *Mind Soc* **14**, 155–167 (2015). <https://doi.org/10.1007/s11299-015-0167-y>

Received

18 December 2014

Accepted

17 April 2015

Published

05 May 2015

Issue date

November 2015

DOI

<https://doi.org/10.1007/s11299-015-0167-y>

Keywords

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